APPENDIX I

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Database Models

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Hierarchical Model

The hierarchical data model organizes data in a tree structure. There is a hierarchy of parent and child data segments. This structure implies that a record can have repeating information, generally in the child data segments. Data in a series of records, which have a set of field values attached to it. It collects all the instances of a specific record together as a record type. These record types are the equivalent of tables in the relational model, and with the individual records being the equivalent of rows. To create links between these record types, the hierarchical model uses Parent Child Relationships. These are a 1:N mapping between record types. This is done by using trees, like set theory used in the relational model, "borrowed" from maths. For example, an organization might store information about an employee, such as name, employee number, department, salary. The organization might also store information about an employee's children, such as name and date of birth. The employee and children data forms a hierarchy, where the employee data represents the parent segment and the children data represents the child segment. If an employee has three children, then there would be three child segments associated with one employee segment. In a hierarchical database the parent-child relationship is one to many. This restricts a child segment to having only one parent segment. Hierarchical DBMSs were popular from the late 1960s, with the introduction of IBM's Information Management System (IMS) DBMS, through the 1970s.

Network Model

The popularity of the network data model coincided with the popularity of the hierarchical data model. Some data were more naturally modeled with more than one parent per child. So, the network model permitted the modeling of many-to-many relationships in data. In 1971, the Conference on Data Systems Languages (CODASYL) formally defined the network model. The basic data modeling construct in the network model is the set construct. A set consists of an owner record type, a set name, and a member record type. A member record type can have that role in more than one set, hence the multiparent concept is supported. An owner record type can also be a member or owner in another set. The data model is a simple network, and link and intersection record types (called junction records by IDMS) may exist, as well as sets between them . Thus, the complete network of relationships is represented by several pairwise sets; in each set some (one) record type is owner (at the tail of the network arrow) and one or more record types are members (at the head of the relationship arrow). Usually, a set defines a 1:M relationship, although 1:1 is permitted. The CODASYL network model is based on mathematical set theory.

Relational Model

(RDBMS - relational database management system) A database based on the relational

model developed by E.F. Codd. A relational database allows the definition of data structures, storage and retrieval operations and integrity constraints. In such a database the data and relations between them are organised in tables. A table is a collection of records and each record in a table contains the same fields.

Properties of Relational Tables:

- Values Are Atomic
- Each Row is Unique
- Column Values Are of the Same Kind
- The Sequence of Columns is Insignificant
- The Sequence of Rows is Insignificant
- Each Column Has a Unique Name

Certain fields may be designated as keys, which means that searches for specific values of that field will use indexing to speed them up. Where fields in two different tables take values from the same set, a join operation can be performed to select related records in the two tables by matching values in those fields. Often, but not always, the fields will have the same name in both tables. For example, an "orders" table might contain (customer-ID, product-code) pairs and a "products" table might contain (product-code, price) pairs so to calculate a given customer's bill you would sum the prices of all products ordered by that customer by joining on the product-code fields of the two tables. This can be extended to joining multiple tables on multiple fields. Because these relationships are only specified at retreival time, relational databases are classed as dynamic database management system. The RELATIONAL database model is based on the Relational Algebra.

Object/Relational Model

Object/relational database management systems (ORDBMSs) add new object storage capabilities to the relational systems at the core of modern information systems. These new facilities integrate management of traditional fielded data, complex objects such as time-series and geospatial data and diverse binary media such as audio, video, images, and applets. By encapsulating methods with data structures, an ORDBMS server can execute comple x analytical and data manipulation operations to search and transform multimedia and other complex objects.

As an evolutionary technology, the object/relational (OR) approach has inherited the robust transaction- and performance-management features of it s relational ancestor and the flexibility of its object-oriented cousin. Database designers can work with familiar tabular structures and data definition languages (DDLs) while assimilating new object-management possibi lities. Query and procedural languages and call interfaces in ORDBMSs are familiar: SQL3, vendor procedural languages, and ODBC, JDBC, and proprie tary call interfaces are all extensions of RDBMS languages and interfaces. And the leading vendors are, of course, quite well known: IBM, Inform ix, and Oracle.

Object-Oriented Model

Object DBMSs add database functionality to object programming languages. They bring much more than persistent storage of programming language objects. Object DBMSs extend the semantics of the C++, Smalltalk and Java object programming languages to provide full-featured database programming capability, while retaining native language compatibility. A major benefit of this approach is the unification of the application and database development into a seamless data model and language environment. As a result, applications require less code, use more natural data modeling, and code bases are easier to maintain. Object developers can write complete database applications with a modest amount of additional effort.

According to Rao (1994), "The object-oriented database (OODB) paradigm is the combination of object-oriented programming language (OOPL) systems and persistent systems. The power of the OODB comes from the seamless treatment of both persistent data, as found in databases, and transient data, as found in executing programs."

In contrast to a relational DBMS where a complex data structure must be flattened out to fit into tables or joined together from those tables to form the in-memory structure, object DBMSs have no performance overhead to store or retrieve a web or hierarchy of interrelated objects. This one-to-one mapping of object programming language objects to database objects has two benefits over other storage approaches: it provides higher performance management of objects, and it enables better management of the complex interrelationships between objects. This makes object DBMSs better suited to support applications such as financial portfolio risk analysis systems, telecommunications service applications, world wide web document structures, design and manufacturing systems, and hospital patient record systems, which have complex relationships between data.

Semistructured Model

In semistructured data model, the information that is normally associated with a schema is contained within the data, which is sometimes called ``self-describing". In such database there is no clear separation between the data and the schema, and the degree to which it is structured depends on the application. In some forms of semistructured data there is no separate schema, in others it exists but only places loose constraints on the data. Semi-structured data is naturally modelled in terms of graphs which contain labels which give semantics to its underlying structure. Such databases subsume the modelling power of recent extensions of flat relational databases, to nested databases which allow the nesting (or encapsulation) of entities, and to object databases which, in addition, allow cyclic references between objects.

Semistructured data has recently emerged as an important topic of study for a variety of reasons. First, there are data sources such as the Web, which we would like to treat as databases but which cannot be constrained by a schema. Second, it may be desirable to have an extremely flexible format for data exchange between disparate databases. Third, even when dealing with structured data, it may be helpful to view it as semistructured for the purposes of browsing.

Associative Model

The associative model divides the real-world things about which data is to be recorded into two sorts:
Entities are things that have discrete, independent existence. An entity's existence does not depend on any other thing. Associations are things whose existence depends on one or more other things, such that if any of those things ceases to exist, then the thing itself ceases to exist or becomes meaningless.
An associative database comprises two data structures:
1. A set of items, each of which has a unique identifier, a name and a type.
2. A set of links, each of which has a unique identifier, together with the unique identifiers of three other things, that represent the source source, verb and target of a fact that is recorded about the source in the database. Each of the three things identified by the source, verb and target may be either a link or an item.
For more information see: The Associative Model of Data

Entity-Attribute-Value (EAV) data model

The best way to understand the rationale of EAV design is to understand row modeling (of which EAV is a generalized form). Consider a supermarket database that must manage thousands of products and brands, many of which have a transitory existence. Here, it is intuitively obvious that product names should not be hard-coded as names of columns in tables. Instead, one stores product descriptions in a Products table: purchases/sales of individual items are recorded in other tables as separate rows with a product ID referencing this table. Conceptually an EAV design involves a single table with three columns, an entity (such as an olfactory receptor ID), an attribute (such as species, which is actually a pointer into the metadata table) and a value for the attribute (e.g., rat). In EAV design, one row stores a single fact. In a conventional table that has one column per attribute, by contrast, one row stores a set of facts. EAV design is appropriate when the number of parameters that potentially apply to an entity is vastly more than those that actually apply to an individual entity.
For more information see: The EAV/CR Model of Data

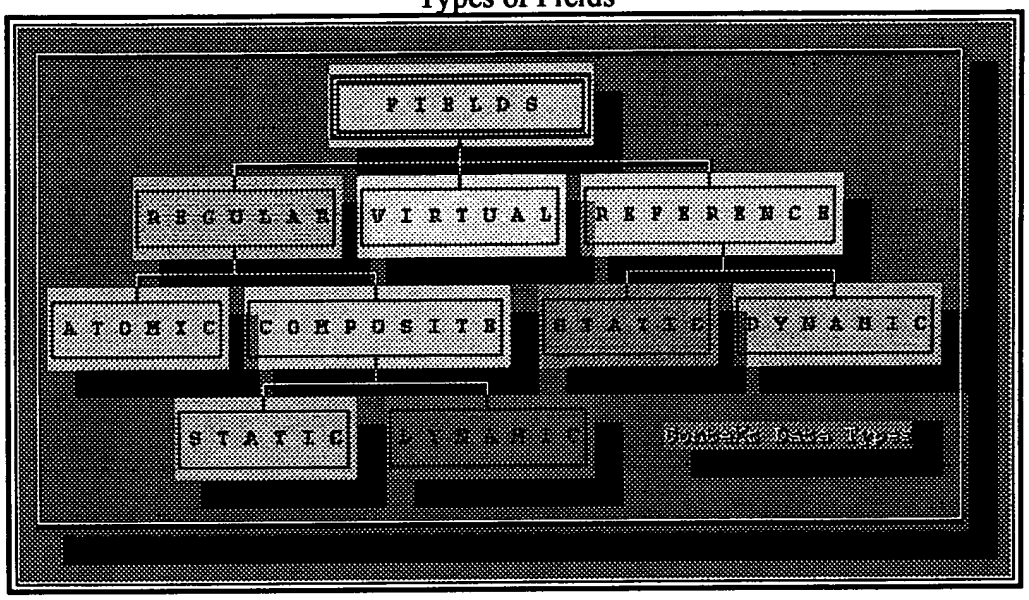
Context Model

The context data model combines features of all the above models. It can be considered as a collection of object-oriented, network and semistructured models or as some kind of object database. In other words this is a flexible model, you can use any type of database structure depending on task. Such data model has been implemented in DBMS ConteXt.

The fundamental unit of information storage of ConteXt is a CLASS. Class contains METHODS and describes OBJECT. The Object contains FIELDS and PROPERTY. The field may be composite, in this case the field contains SubFields etc. The property is a set of

fields that belongs to particular Object. (similar to AVL database). In other words, fields are permanent part of Object but Property is its variable part.
The header of Class contains the definition of the internal structure of the Object, which includes the description of each field, such as their type, length, attributes and name.
Context data model has a set of predefined types as well as user defined types. The predefined types include not only character strings, texts and digits but also pointers (references) and aggregate types (structures).

Types of Fields



A context model comprises three main data types: REGULAR, VIRTUAL and REFERENCE. A regular (local) field can be ATOMIC or COMPOSITE. The atomic field has no inner structure. In contrast, a composite field may have a complex structure, and its type is described in the header of Class. The composite fields are divided into STATIC and DYNAMIC. The type of a static composite field is stored in the header and is permanent. Description of the type of a dynamic composite field is stored within the Object and can vary from Object to Object.

Like a NETWORK database, apart from the fields containing the information directly, context database has fields storing a place where this information can be found, i.e. POINTER (link, reference) which can point to an Object in this or another Class. Because main addressed unit of context database is an Object, the pointer is made to Object instead of a field of this Object. The pointers are divided on STATIC and DYNAMIC. All pointers that belong to a particular static pointer type point to the same Class (albeit, possibly, to different Object). In this case, the Class name is an integral part of the that pointer type. A dynamic pointer type describes pointers that may refer to different Classes. The Class, which may be linked through a pointer, can reside on the same or any other computer on the local area network. There is no hierarchy between Classes and the pointer can link to any Class, including its own.

In contrast to pure object-oriented databases, context databases is not so coupled to the programming language and doesn't support methods directly. Instead, method invocation is partially supported through the concept of VIRTUAL fields.

A VIRTUAL field is like a regular field: it can be read or written into. However, this field is not physically stored in the database, and in it does not have a type described in the scheme. A read operation on a virtual field is intercepted by the DBMS, which invokes a method associated with the field and the result produced by that method is returned. If no method is defined for the virtual field, the field will be blank. The METHODS is a subroutine written in C++ by an application programmer. Similarly, a write operation on a virtual field invokes an appropriate method, which can changes the value of the field. The current value of virtual fields is maintained by a run-time process; it is not preserved between sessions. In object-oriented terms, virtual fields represent just two public methods: reading and writing. Experience shows, however, that this is often enough in practical applications. From the DBMS point of view, virtual fields provide transparent interface to such methods via an aplication written by application programer.

A context database that does not have composite or pointer fields and property is essentially RELATIONAL. With static composite and pointer fields, context database become OBJECT-ORIENTED. If the context database has only Property in this case it is an ENTITY-ATTRIBUTE-VALUE database. With dynamic composite fields, a context database becomes what is now known as a SEMISTRUCTURED database. If the database has all available types... in this case it is ConteXt database!

For more information see: Concepts of the ConteXt database

The evaluation version of DBMS ConteXt you can download from:UnixSpace Download Center